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AUTHOR Yanagihara, Masafumi; Sako, Akihito
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ABSTRACT

This study investigates a negative component (N220) of visual evoked potential (VEP) which increases as certain cognitive processes are activated. Nine experimental conditions were designed by combining three stimulus and three task conditions. Letters were used as verbal stimuli, matrix patterns were used as nonverbal stimuli, and white light was used as a non-structural stimulus. Non-response, comparison and counting tasks were performed. Subjects were eight 8- and 9-year-old children who had normal visual acuity and average intelligence. All were right-handed and were confirmed to have neither EEG dysrhythmia nor neurological abnormality. Stimuli were presented for approximately 500 - 800 msec on a viewing screen placed 80 cm in front of the subjects. The VEP was recorded in the left parietal, the right parietal and the mid-occipital regions (by the International 10 - 20 method) using Ag - AgCl electrodes referenced to the left earlobe. Cortical activity was amplified by Nihon Kohden ME - 135D Polygraph and recorded on FM magnetic tape for later analysis. Results indicate that N220 increases under conditions of response task combined with structured stimuli. The increase is especially clear when same-different judgments are elicited with verbal stimuli. A clear fluctuation in the sensory non-specific parietal region is noted when compared to the sensory specific occipital region, indicating that N220 is not entirely due to physical characteristics of the stimuli. Rather, N220 reflects the endogenous process necessary to perform the cognitive tasks. (Author/RH)

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Tokyo Gakugei University
Koganei, Tokyo
Japan

Masafumi Yanagihara
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# NEGATIVE COMPONENT OF VISUAL EVOKED POTENTIAL IN CHILDREN WITH COGNITIVE PROCESSING

Masafumi Yanagihara

The Research Institute for the Education of Exceptional Children

Tokyo Gakugei University

and

Akihito Sako

Asahigawaso College of Welfare

In previous research on children, we found a negative component of visual evoked potential (VEP) which increases at the activation of some cognitive proceses and named it N 220 (Yanagihara & Sako, 1979). The reason why we named it N 220 was because the component appeared to be different in its nature as compared with that of N 200 (Simson, Vaughan, & Ritter, 1976). The negative component, N 220, is increased more when the subject is asked to push the key in response to the letter stimuli than in the same task to the white light. In addition, there is no increase of that component when the subject is asked to merely look at the same letter stimuli. However, it is not completely clear whether this increase is due to the difference of stimulus material or of the nature of the task.

Then, at this study we intend to examine this negative component systematically in clarifying the question stated above. We further aim to study the psychological process underlying the negative component, N 220.

## METHOD

### 1. Experimental Design

The experiment was designed to evaluate the effect of stimulus-response properties by considering the combination of the stimulus material and the task. For stimulus material, we used letters for verbal stimuli and matrix pattern for nonverbal stimuli(Figure 1). In addition, we used white light, which is non-structual stimuli. For letter stimuli, letters from two

The upper and the lower indicate letter stimuli and matrix pattern stimuli, respectively.

Figure 1 Sample of Stimulus Materials

Japanese alphabets - hiragana and katakana, were presented in pairs. Likewise, the matrix patterns were presented in pairs and all consisted of 3 × 3 cells. All three types of stimuli were presented for the following three tasks, resulting in 9 experimental conditions.

(a) Non-response task; The subjects were instructed only to gaze at a fixation point in the center of the screen regardless of the stimulus. The purpose of the fixation point was to restrain eye movement.

(b) Comparison task; The subjects were told to judge whether the two stimuli were "same" or "different" and to respond by pushing the button

as quickly and as accurately as possible. In the white light session, the task was the simple reaction of responding immediately after the presentation of the stimulus. The letter pairs in the letter session are limited to the same alphabet. Thus, as in the matrix pattern session, the subjects could respond by physical matching. The proportion of "same" and "different" pairs was the same in both sessions.

(c) Count task; The subjects were instructed to count the number of times that a target stimulus appeared and to disregard all other stimuli. After the session, they were asked to given an oral report to confirm the accomplishment of the task. In the letter session, there were five letters (a,i,u,e, and o) and these made up 30 % of the total slides. In this case, name matching was necessary since hiragana and katakana were mixed. In the matrix pattern session, the rate of signal appearence was also 30 %. In the white light session, the total number of stimuli presented had to be counted.

2. Subjects

The subjects were 8 children aged 8 and 9 (7 boys and 1 girl). They were chosen on the basis of normal visual acuity and average intelligence and academic performance. All were right-handed, and were confirmed to have neither EEG dysrhythmia nor neurological abnormality. Some of them did not participate in some of the sessions (see Figure 2, 3, 4).

3. Experimental System and Procedure

The stimuli were presented on a viewing screen (42 × 28 cm) placed 80 cm in front of the subjects by releasing the electronic shutter equipped with the slide projecter. The subjects viewed the stimuli with both eyes while sitting in an electro-magnetically shield room. The stimulus duration

was approximately 500 - 800 msec, and the intervals between stimuli varied randomely from 2 to 6 sec.

The instructions were given at every session. After confirming that the task was fully understood with about 10 practice trials, it was proceed to 40 - 80 experimental trials. In order to limit the time required to 60 minutes or less, all the subjects participated in the experiment twice.

The VEP was recorded in the left parietal ($P_3$), the right parietal ($P_4$), and mid-occipital ($O_z$) regions (by the International 10 - 20 method) using Ag - AgCl electrodes referenced to the left ear lobe. These cortical activity was amplified by Nihon Kohden ME- 135D Polygraph (time-constant 1.5 sec) and recorded on FM magnetic tape for later analysis. Excessive EMG and other artifacts were excluded from analysis.

VEP was averaged using a Nihon Kohden ATAC 501-10S signal averager in each experimental conditions at 30 times. Analysis time was 1024 msec and sampling interval was 4 msec.

## RESULTS

Figure 2 - 4 show the VEP of each subject under each experimental condition. (on the left is the recording from the $P_3$, and on the right is that from the $O_z$.) The figures were drawn so that the downward deflections are positive. The shaded parts are the negative components which correspond to N 220. These appear when the latency increases to arround 200 msec.

Figure 5 is the grand averaged VEP across subjects. It shows that there are increases or decreases of the negative component ($N_2$) depending on the experimental condition. However, in all these conditions, the basic

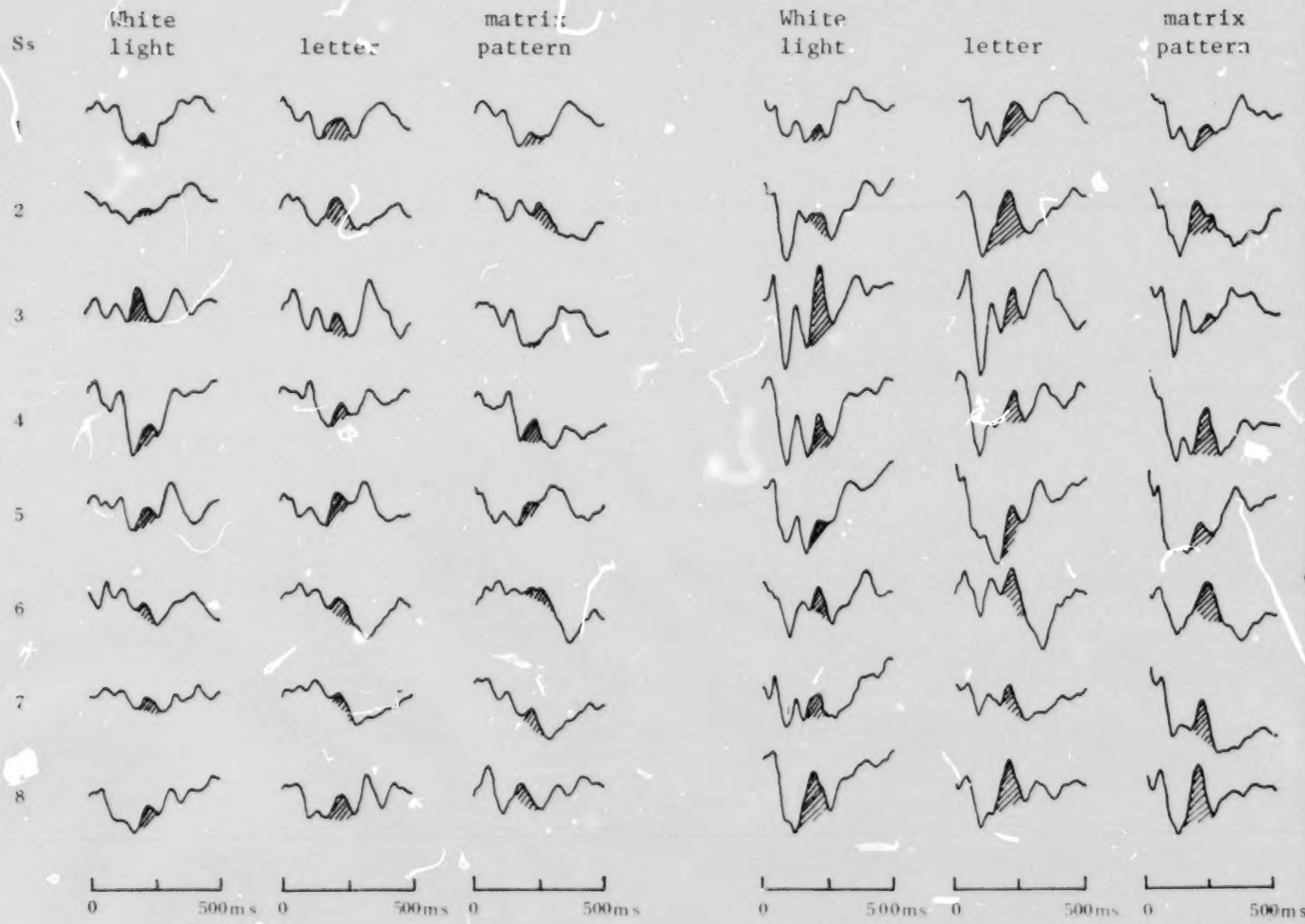


Figure 2 VEPs under Non-response Tasks

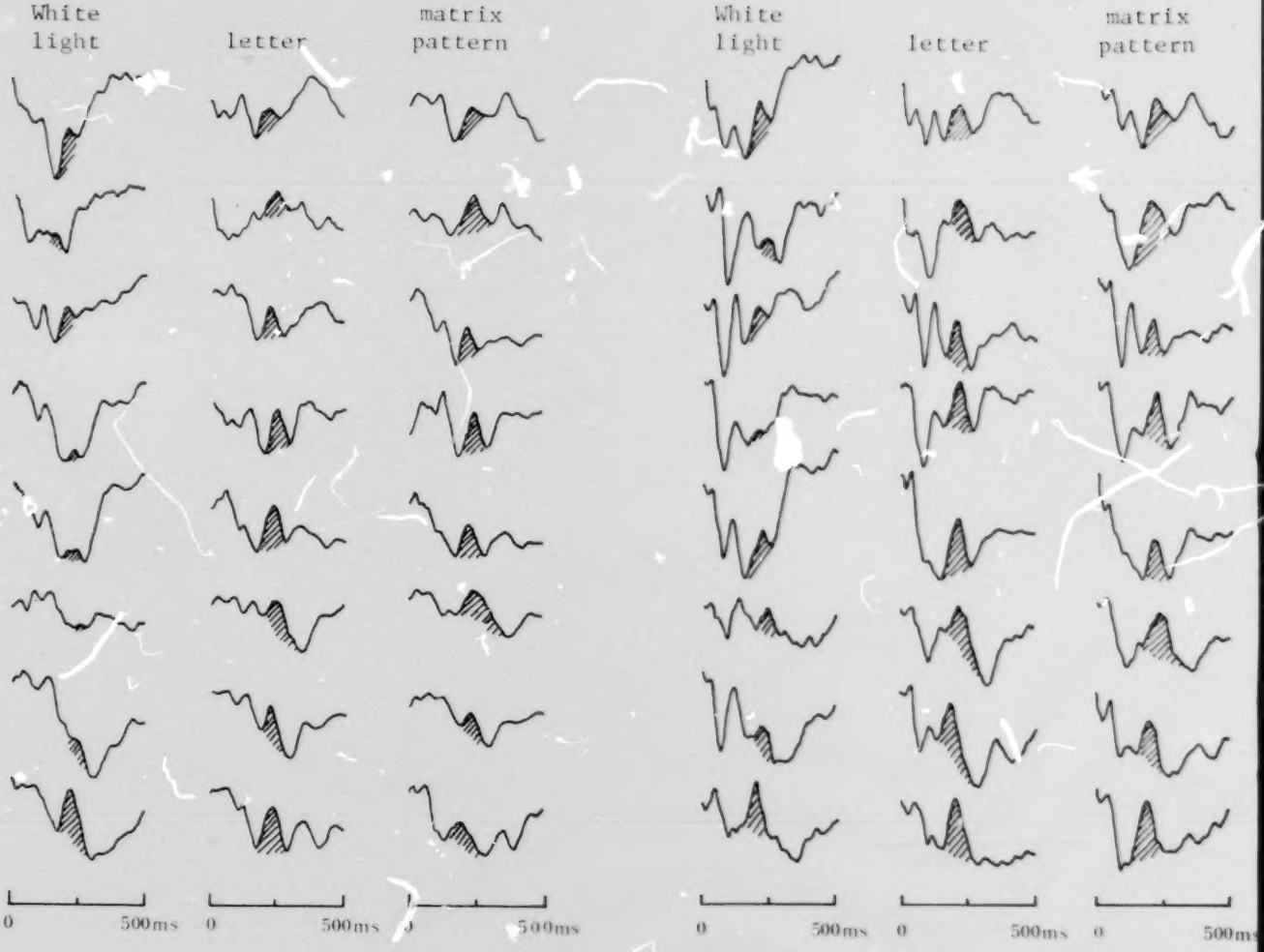


Figure 3 VEPs under Comparison Tasks

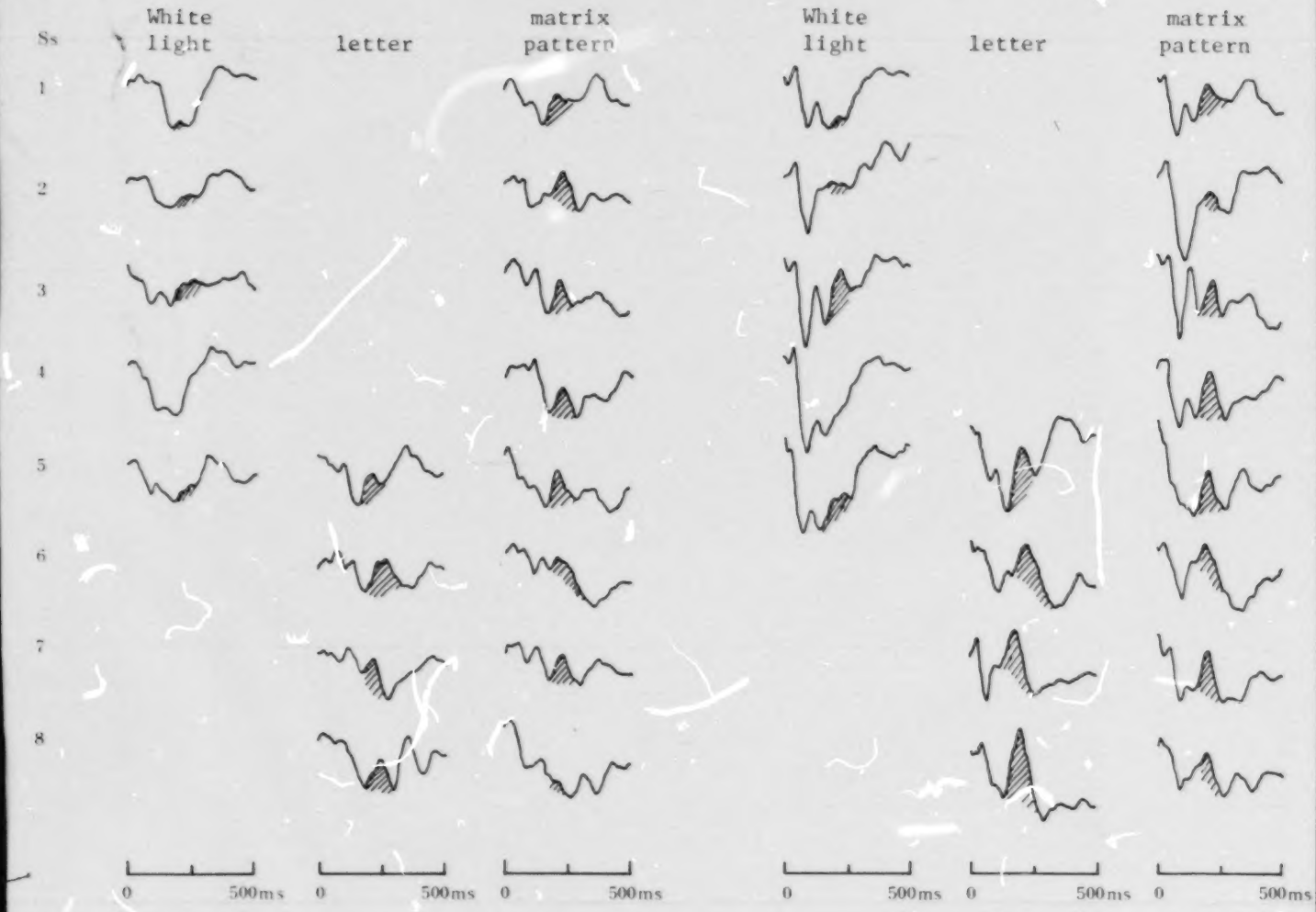


Figure 4 VEPs under Count Tasks

wave forms are seen, showing the characteristic patterns of the occipital and parietal regions.

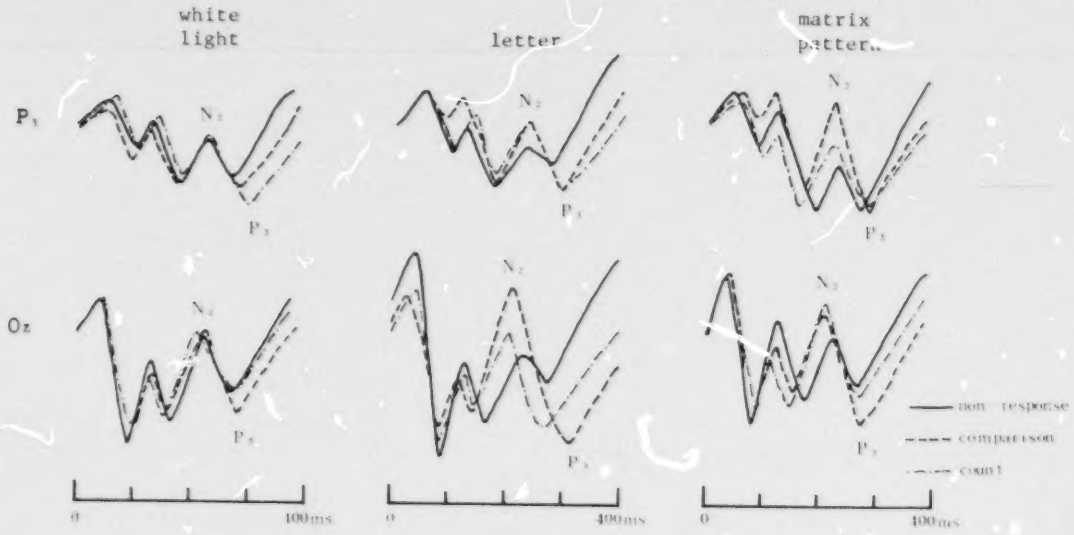


Figure 5 VEPs under All Experimental Conditions

Table 1 shows the peak to peak amplitude of $N_2$ and the consecutive $P_2$. The amplitude of this negative component of the parietal region differs according to both the kind of task ($F=22.71$ $df=2$ $p < .01$) and the stimulus material ($F=17.95$ $df=2$ $p < .01$). In the non-response task, there is no difference in the amplitude values regardless of the stimulus material, and the values are generally low. The largest amplitude was the 18.6 μv from the letter comparison condition, and the next largest values were those from the letter count, matrix pattern comparison, and matrix pattern count conditions. The value from the remaining conditions are all low.

Essentially the same results were obtained from the occipital region as from the parietal region. However, it is not the case that the letter

comparison is particularly high. Rather there is a tendency for the amplitude to increase when letter or matrix pattern stimuli are used in two tasks.

These results lead to the conclusion that there is clear fluctuation in N 220 in the parietal region which is a sensory non-specific area and that N 220 is especially easy to evoke in the letter comparison task.

Table 1 Mean peak to peak amplitude ($N_2$ - $P_2$) under various experimental conditions (μV)

| Task / Stimulus | $P_3$ | | | $O_z$ | | |
|---|---|---|---|---|---|---|
| | non-resp. | comp. | count. | non-resp. | comp. | count. |
| white light | 6.6 | 9.0 | 2.8 | 10.1 | 5.6 | 9.6 |
| letter | 10.1 | 18.6 | 11.3 | 15.0 | 25.3 | 21.3 |
| matrix pattern | 11.1 | 12.0 | 12.7 | 10.1 | 16.9 | 17.1 |

Table 2 shows the standard scores which are converted from the peak to peak amplitude under various experimental conditions with a same subject. The use of the standard score was due to the interhemispheric difference of baselines. The scores for the left and right parietal are compared. ($P_4$ was not recorded in the matrix pattern sessions) In the white light non-response condition (e.g., eye open only), the amplitude for the right parietal is greater than that for the left. By contrast, in the letter comparison and the letter count conditions the amplitude for the left is greater. (sign-rank test, $p < .05$ in seven of eight subjects) These results strongly suggest that the degree of cortical activation changes between hemispheres

depending on the experimental conditions.

Table 2 Mean standard scores converted from peak to peak amplitude under all experimental conditions within subjects

| Task / Stimulus | non-response | comparison | | count | |
|---|---|---|---|---|---|
| | white iight | white light | letter | white light | letter |
| left parietal | -.47 | -.31 | 1.18 | -1.40 | -.02 |
| right parietal | -.21 | .15 | .65 | .23 | .55 |

## DISCUSSION

The purpose of this experiment was to investigate the psychological process underlying N 220. The characteristics of the negative component can be summarized as follows:

(1) N 220 increases when a response task is used with stimuli which have some kind of structure. This increase is especially clear when same-different judgements are elicited with verbal stimuli. (2) A clear fluctuation in the sensory non-specific parietal region is noted when compared to the sensory specific occipital region. (3) It presents a strong possibility that the variation between the left and right parietal region is due to the nature of the tasks. These findings indicate that N 220 is not due entirely to physical characteristics of the stimuli. Rather N 220 reflects the endogenous process necessary to perform these tasks.

An increase of N 220 was found in the comparison and count response tasks. In these two tasks, similar processes of "stimulus coding" (STM storage) and of "comparison" are necessary. There is a strong

possibility that all these processing stages are reflected in the negative component.

The reason N 220 became especially clear in the letter comparison seems to be related to the influence of linguistic facilitation such as verbal coding in the reaction time paradigm, a paradigm which requires speed response. There is a possibility that name matching actually has taken place instead of physical matching which is much simpler in this experimental condition.* Considering the fact that there was no increase of N 220 with the white light stimulus material in the same response task. These could have been a strong influence of the coding process necessary for stimulus processing among all the processing stages.

Waves similar to N 220 also appear in the digit matching tasks by Adam & Collins (1978), and in the letter matching by Thacher (1977), but they are not specifically pointed out. Many of the N 200's reported previously are considered to be $N_2$ - $P_3$ complexes, and their positive going returns as P 300 are considered to have the same value (Donchin, Ritter, & McCallum, 1978; Demaire & Coquery, 1976 )

If we interpret P 300 as the evaluation time until reaction (Kutas, McCarthy, & Donchin, 1977 ) and estimate that there is a latency of 500-1000 msec in children (Courchesne, 1977), P 300 should appear in our letter comparison practice. (the positive component shown by the shaded area in the Figure 6). Therefore, the N 220 of this experiment must have appeared

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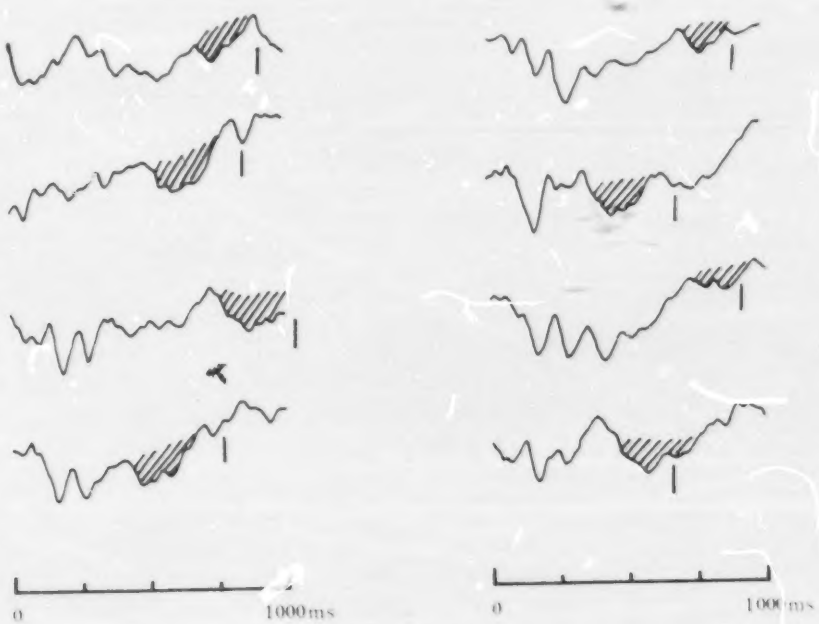
* Note: A "same" reactions is 150 - 200 msec faster than "different" reaction. At this time, the amplitude increases in the left hemisphere.

separately from P 300. This might mean that N 220 is different N 200. Therefore, for the time being we suggest that the negative component which increases in tasks including a comparison stage be called N 220. We have demonstrated the possibility that this N 220 increases in linguistic processes, and we would like to examine this problem further.




A shaded area and a mark indicate P 300 and mean reaction time, respectively

Figure 6 VEPs under Letter Comparison Tasks

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